Music for a Variety of Difficult Situations

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in

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by

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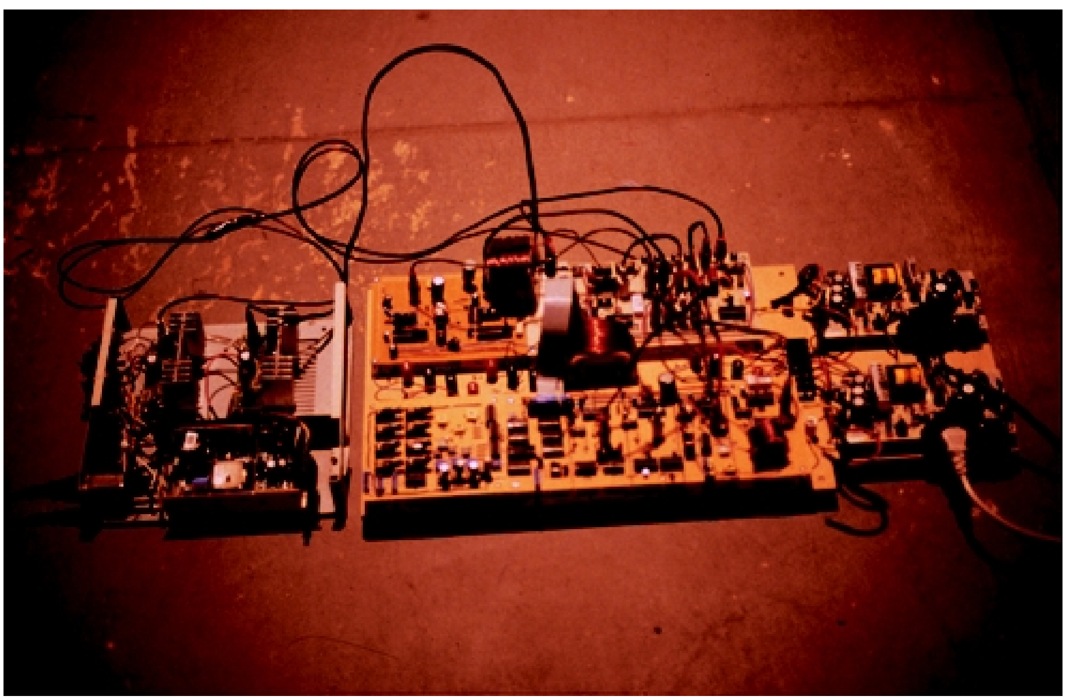
Most importantly, thank you to my parents and family for supporting me in any direction life decides to take me.

Abstract

This thesis describes a sculptural sonic installation entitled *Music for a Variety of Difficult Situations.* This piece is comprised of several elements including music, electronics, and sculpture.

Music for a Variety of Difficult Situations takes the following physical form:
A hospital gurney (c. 1950) sits in a room illuminated by a small lamp. Behind the gurney are three speakers which are arranged in a pyramidal configuration and angled in such a way that optimal listening is achieved while lying flat on the clinical platform. Music is played through the speakers using custom electronics which are placed in a metal tray below the gurney. All sound originates from the electronics which were designed to perpetually generate sound.

The relationship between the elements of sound, electronics, visual components, and the psychological considerations are described at length in the following three chapters. The first chapter describes my artistic methodology and aesthetic views. It also relates these views to other artists and composers who have worked in a similar manner, and to whose history I am indebted. The second chapter is a purely objective description of the sound, and rhythmic structure of the music. The third chapter is an in depth discussion of the circuitry. It assumes a thorough understanding of electronics. Several photographs of the piece are included in this document as well as a CDROM which contains audio and video documentation.



Chapter 1: Artistic Methodology

> "Put yourself in as passive, or receptive, a state of mind as you can…Write quickly, without any preconceived subject, fast enough so that you will not remember what you're writing…The first sentence will come spontaneously, so compelling is the truth that with every passive second there is a sentence unknown to our consciousness which is only crying out to be heard." [1]

In this statement André Breton, one of the first generation of Surrealists, describes the practice of automatic writing. The concept was expanded to include 'automatic drawing,' which was advocated by many other Surrealists at the time. It is most often categorized by extremely fast and fluid linear drawing. Later on, automatic drawing was adopted by a significant number of other artists as a way to generate ideas and as a way to defy and reveal their natural tendencies. For example, Ellsworth Kelly, who few associate with the Surrealist movement, wrote about the importance of automatic drawing. [2]

For André Masson, another early Surrealist, manual speed was the only important prerequisite: "When one goes very quickly, the drawing is mediumistic… the hand must move quite rapidly," he instructs. Speed, however is relative. The result is always the same for anyone who practices automatism: Ideas are generated, thoughts are revealed, and natural sensibilities are cultivated and challenged through *activity*.

It is in the latter sense that I consider my work related to this philosophy. *Music for a Variety of Difficult Situations* was not planned. It was exposed gradually through the process of incessant exploration of tangents, and through a very slow exploration of whatever came to mind. There is a freedom in not being too discriminating in my course of action or whether I should act on a particular idea. This freedom almost always results in unexpected artistic discoveries.

More explicitly, my general approach is as follows:

1. **Start anywhere**.

   Explore any idea that seems even remotely interesting. Realize that there is almost no chance that the final piece will conclude in a preconceived manner. This understanding means that I can literally start with any initial idea, because I realize that this idea will eventually be discarded. Although my initial ideas are always interesting to me, they may not be ideas useful to my work— eventually it doesn't matter.

2. **Continue.**

   I keep working, reworking and reevaluating until I notice something highly unusual or particularly fascinating. Most of the time these revelations are appreciated during a time of extreme uncertainty about where the piece is headed. Often this uncertainty approaches a crisis situation. By crisis I mean that I might feel like starting all over again. However, this has happened so many times, that I simply work through this period. This state of extreme uncertainty and disorientation is the most essential period, since it is here that radical action is taken, and old ideas are thrown away. With a newly discovered clarity, the piece finishes itself directly to the end.

   Figure 1 on the following page illustrates this idea.

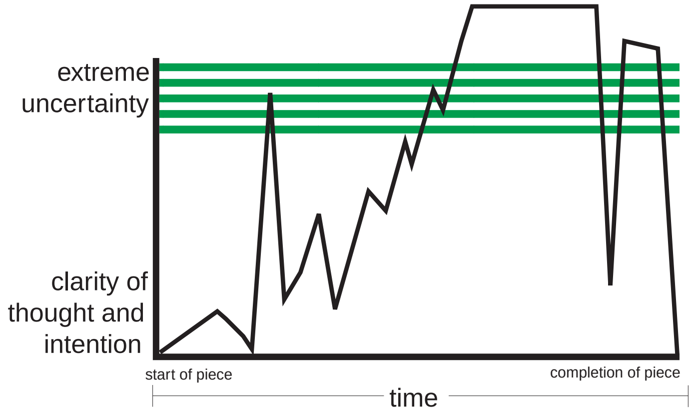


Fig 1.

Why Electronics?

Electronics lends itself well to this tangential method of exploration. Building and designing electronics from discreet parts is a very slow and meditative process. Because of the time involved, it allows for careful listening. Sometimes it may take several days to develop a small circuit during which time I begin to understand a great deal about the subtleties and nuances of the circuit. Although it is not true in a strictly acoustic sense, I feel that the sound was my invention. I am able to fine tune it and make modifications as desired, exploring any surprise developments at will.

My view of the creative potential of electronics has been preceded by a large number of creative artists in recent history. David Tudor, Gordon Mumma, David Rosenboom are well known composers who have worked in a similar way. They all share the idea that this element of *discovery* is extremely important, and that the medium of electronics is well suited for such discovery. David Tudor when asked to describe the title of his group called “Composer’s Inside Electronics,” explains,

“I purposely selected that title because the people who were working with me

> were working in that manner. *That is, instead of using electronics as given instruments, they were working with the circuitry, trying to alter it, influence it, discover what it can do and that's a totally different method of working in electronics and I thought it should be propagated."* [3]

This philosophy lead Tudor to explore circuitry that had very unusual and unpredictable behavior. John S. Adams writes,

> "it was his [Tudor's] desire for the unpredictable and the unique that inspired his in-depth study of the principles of amplification and feedback." [4]

Curiously, it was not Tudor's interest in amplification that lead him into his "in-depth study of ... amplification." It was his desire for the unpredictable and unique. He became an expert on amplification almost by accident. This approach to electronics, is fundamentally different than an engineering approach. In his words,

> "Rather than taking the engineering criteria for granted, I have tried to discover what actually is unique. I recall my own astonishment, years ago, when I attempted to explain the kind of complex hook-ups that I make in electronics, I mean, many people have asked me about them and it's not an easy thing to explain. Once a physicist came and said, 'well, what do you have here' and he looked at everything and he said, ' Oh yes, you have only amplifiers'. And it was like a light going on in my head. Looking at the map in that light, I can understand why it's possible to gain unpredictable results from something which has predictable specifications." [3]

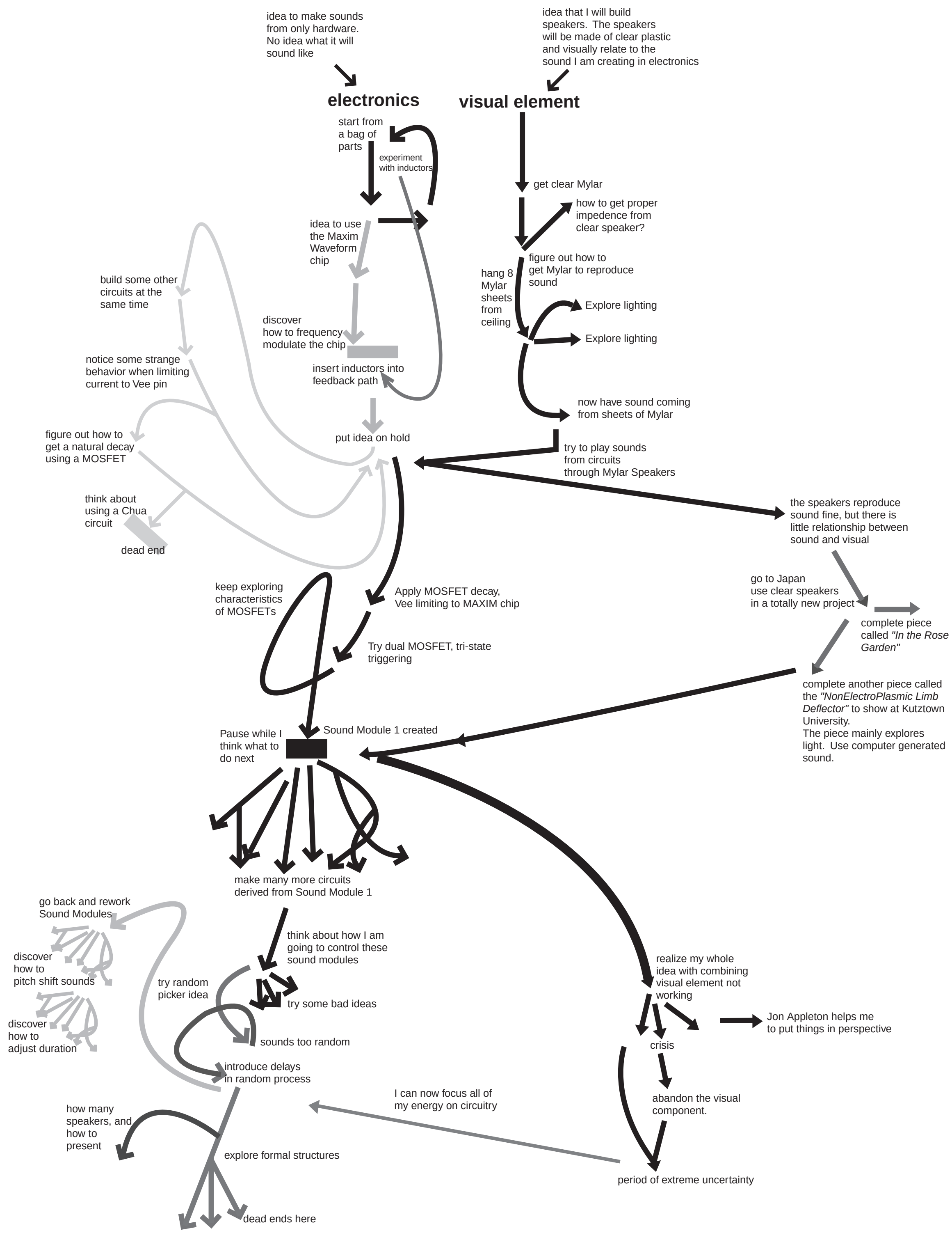
This approach of going “inside electronics” as Tudor puts it, has been echoed by David Rosenboom,

> “During the late 1960’s, I experimented extensively with modular, analog computing techniques in order to find unique ways of devising live, electronic music systems for my pieces. I was particularly interested in studying the complex behavior of unstable circuits...
>
> I did not carry out a formal analysis of my circuits behavior at the time of its invention. *However, through intensive listening and a strong musical attitude,* I was able to discover and explore exciting sonic terrain. [5]

A Detailed Path

Since the type of circuits and sounds I created were only discovered through experimentation and not preconceived, it made planning this project difficult considering the deadlines imposed by the academic calendar. This was discussed in great depth at the outset. However, the path to completing *Music for a Variety of Difficult Situations* was far more divergent than anything I have done in the past. The graphic flow chart on the next page illustrates the degree of complexity. For practical reasons, only the first thirty percent of the process is represented.

The chart shows that *Music for a Variety of Difficult Situations* began as a piece which incorporates sonic elements as well as a Mylar visual component. In many ways, it was an outgrowth of a very recent piece called *The ElectroPlasmic Limb Deflector* (2000), in which I created a twenty-five foot loudspeaker out of reflective Mylar. (See Appendix B) The Mylar was stretched from the ceiling



idea to make sounds from only hardware. No idea what it will sound like
idea that I will build speakers. The speakers will be made of clear plastic and visually relate to the sound I am creating in electronics
electronics
visual element
start from a bag of parts
experiment with inductors
get clear Mylar
how to get proper impedence from clear speaker?
idea to use the Maxim Waveform chip
figure out how to get Mylar to reproduce sound
hang 8 Mylar sheets from ceiling
Explore lighting
Explore lighting
build some other circuits at the same time
discover how to frequency modulate the chip
insert inductors into feedback path
notice some strange behavior when limiting current to Vee pin
now have sound coming from sheets of Mylar
put idea on hold
figure out how to get a natural decay using a MOSFET
try to play sounds from circuits through Mylar Speakers
think about using a Chua circuit
the speakers reproduce sound fine, but there is little relationship between sound and visual
dead end
keep exploring characteristics of MOSFETs
Apply MOSFET decay, Vee limiting to MAXIM chip
go to Japan use clear speakers in a totally new project
complete piece called "In the Rose Garden"
Try dual MOSFET, tri-state triggering
complete another piece called the "NonElectroPlasmic Limb Deflector" to show at Kutztown University. The piece mainly explores light. Use computer generated sound.
Pause while I think what to do next
Sound Module 1 created
make many more circuits derived from Sound Module 1
go back and rework Sound Modules
think about how I am going to control these sound modules
discover how to pitch shift sounds
try random picker idea
realize my whole idea with combining visual element not working
try some bad ideas
discover how to adjust duration
sounds too random
crisis
Jon Appleton helps me to put things in perspective
introduce delays in random process
I can now focus all of my energy on circuitry
abandon the visual component.
how many speakers, and how to present
explore formal structures
period of extreme uncertainty
dead ends here

diagonally to the floor. Sound came from the surface of the membrane, and as a result of its vibration reflected light onto the viewer's face and the surrounding space.

Music for a Variety of Difficult Situations was originally meant to continue where *Limb Deflector* left off. My idea was to create a playback system out of clear plastic Mylar, thereby creating an almost invisible speaker system. And where *Limb Deflector* used CD players as its source of sound, I now wanted to create all the sound in electronics—with no prerecorded material used. However, as can be seen from the chart on the previous page, the visual element took its own path, and it was difficult to establish any relationship between the circuits I was building and this visual component. As a result, I was forced to abandon this route and move into the period of extreme uncertainty illustrated in Fig 1, page 3.

The indirect process described above was essential to shaping the outcome of *Music for a Variety of Difficult Situations.* It also spawned two new pieces—*The **Non**ElectroPlasmic Limb Deflector* and *In the Rose Garden,* both of which have generated ideas for future endeavors. This is a prime example of how a continued and steady involvement with an idea, *even if the idea is a bad one*, is essential to the development of my work.

The Installation

There is considerably more to *Music for a Variety of Difficult Situations* than the sonic and electronic component. There is, after all, an antique hospital gurney, three speakers arranged in a pyramid configuration, and a very particular type of low level lighting.

This final presentation of the piece was somewhat surprising to me. In many ways the mood is very dark – a state I usually avoid in my work. It also seemed to have an ambiguous dreamlike character. Perhaps it was music for the state of mind in between sleep and consciousness. Or perhaps it was music for surgery, death, survival or recuperation? The hospital gurney could pertain to any of these situations.

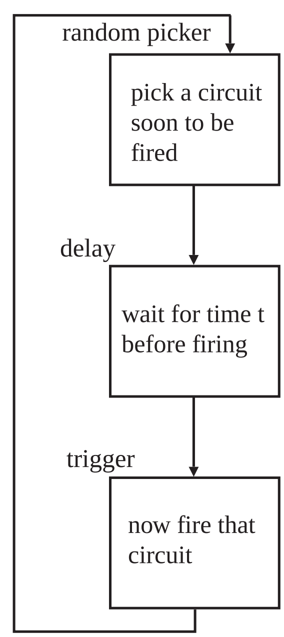
It should be noted, however, that some have described the quality of the sound as humorous, comfortable to listen to, and relaxing. Of course the interpretation is somewhat dependent on whatever life experiences the viewer brings with them.

The themes of death and danger in the piece did bring to the forefront of my mind thoughts and fears about a particular situation in my life—a situation which is difficult for me to address in prose or verbal communication. Perhaps, the uncovering of topics difficult to deal with or think about is the function of this recent work.

Chapter 2: The Music

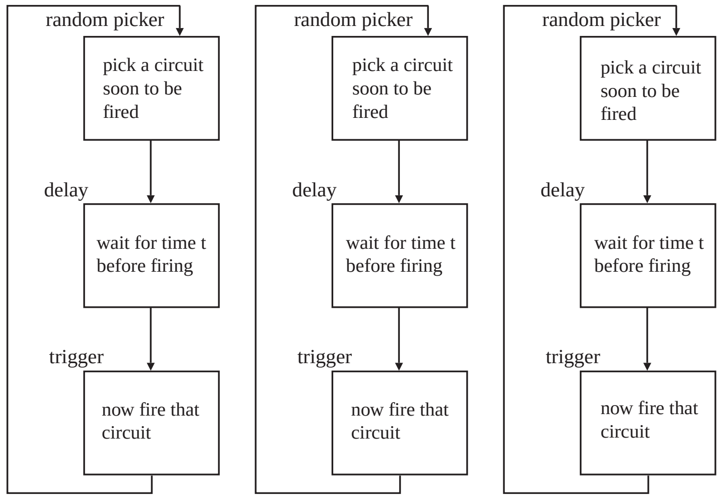
Music for a Variety of Difficult Situations makes use of eight sound generating circuits called modules. Each module can be thought of as generating its own unique and repeatable sonic event. These sonic events consists of peculiar frequency sweeps and amplitude envelops, spontaneous harmonic and inharmonic noise bursts. Certain parameters of the modules can be controlled such as duration and the stability of the circuit (called variance). Therefore, the sound of each module can vary gradually over time or change abruptly.

Music for a Variety of Situations begins when the power switch is turned on. In principle, it will continue to generate sound forever in time, or unless the unit is turned off. The perpetual nature of this machine is due to the fact that a module not only generates sound, but also signals to another module to fire after a selected delay time. The music can therefore be thought of as events in a controlled chain reaction.



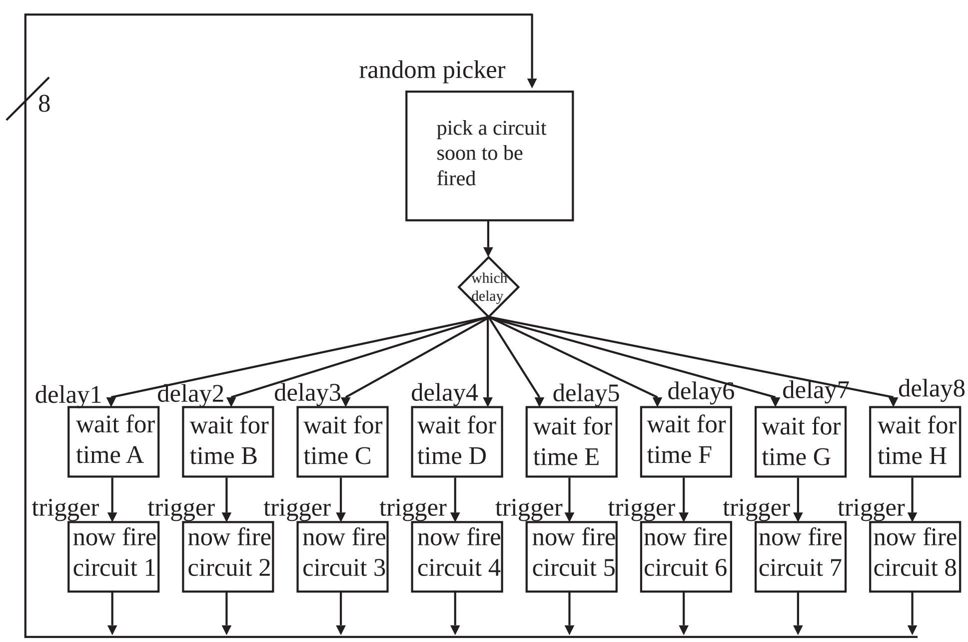
To achieve this function, random selector circuitry chooses a module. After a delay, that module is fired— its sound generated. This can be seen at right:

This configuration will generate only one event at a time. If an asynchronous system like the one below could be devised, several chain reactions could occur simultaneously.



The most important factor in the above model is the delay time. The delay time has the following effect. If the delay is fixed, the sequence of events will be completely periodic, with each sound being triggered after the same period of silence. However, considering the unstable nature of the sound modules, it seemed more appropriate to have an irregular period between events.

Since there are eight sound circuits, I decided to have eight distinct delay times. This provides a more complex rhythmic structure. This might be done as below. Note that



while one circuit is still in its delay state, another can be firing and choosing another circuit.

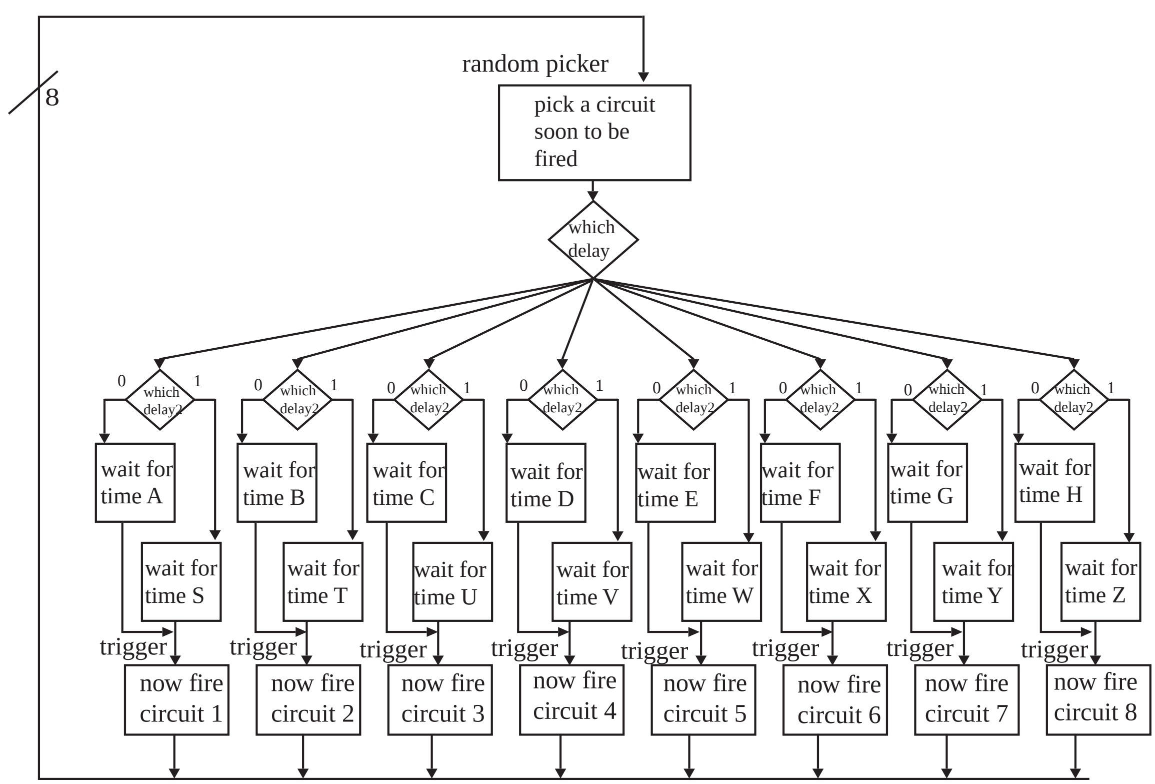
The delay times (in seconds) are as follows:

time A = .5; time B = 3; time C = .5; time D = .5; time E = 6; time F = 7, time G = 9; time H = 17.

Since these times me be either extremely long or short, the rhythmic sequence from the values above is as follows, with each ‘|’ symbol representing a randomly chosen sound module along an x axis of time. A rhythmic clustering occurs.

||| || |||||||||| | | | || | |||| ||||||||||| || | |||| ||||| ||| |

The above model can be expanded by having an additional bank of eight delay times. A circuit could then have two possible delay times.



The delay times (in seconds) for this second bank of delays is as follows:

time S = 10; time T = 11; time U = 12; time V = 13; time W = 14; time X = 15; time Y = 16; time Z = 17.

Because of the overlapping delay times a similar clustering occurs, but with more time between them. The rhythmic sequence which results is as follows:

|| | | | | ||| | | | | | | | ||

The circuitry now has two modes of operation. One very active mode where the chain reaction is rapid, and another mode where the spacing between events is greatly increased. Additional flexibility is available since the transistor which regulates these two modes, can be in a “halfway” state. Thus, the system can be in a transitional area where the rhythmic sequence is a combination of these two operational modes. Below is a comparison of the three possible rhythmic states.

Delay Bank 1 (65% rhythmic activity)

||| || ||||||||| | | | || | |||| |||||||||| || | |||| ||||| ||| |

Delay Bank 2 (30% rhythmic activity)

|| | | | | ||| | | | | | | | ||

“halfway state” (~ 31 – 65% rhythmic activity)

|| | |||| | | | || ||| | ||| | | | | | | || | | |

Duration Control

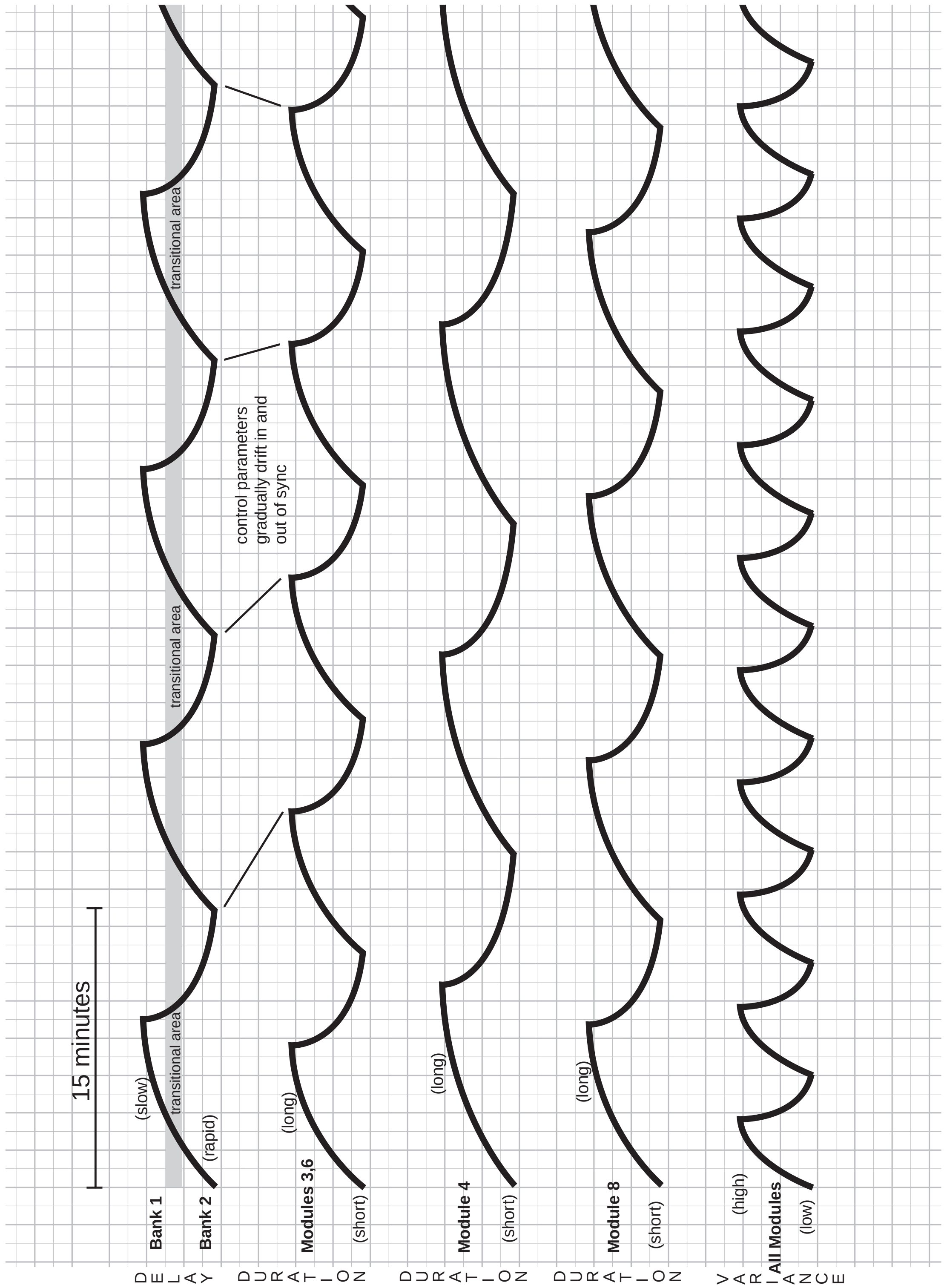
As mentioned above, the duration of each module can be controlled. The effect is not simply that the event occurs over an extended period of time. Rather, the sound is stretched out, with every detail of the sound becoming more apparent as the duration is expanded. This is not a digital time stretching, but rather an analog procedure which is due to the nature of the transistor used to fire the circuit. The duration time varies from a fraction of a second to fifteen seconds. Duration control is applied to modules three, four, six, and eight.

Variance Control

Each sound module has a feedback path from its output to a control which regulates the frequency. If the electrical current in this path is partially obstructed, the module behaves erratically resulting in staccato behavior and harmonic noise. Please see Chapter 3 for the practical implementation. Variance control is applied to all of the modules except number five.

Over Time

The parameters of duration, variance, and delay change over a period of time. Generally, the delay bank, and the duration controls oscillate at the rate of one cycle per fourteen minutes. However, there are three duration control circuits to control four modules. Three asynchronous timer circuits can never be perfectly synchronized, the reasons for which are discussed in the technical discussion of Chapter 3. This results in large number of possible combinations of durations. This asynchronous characteristic is also true of the variance and delay bank control, and it is what gives the piece its mutational rhythmic structure. The timing diagram on the following page illustrates this clearly.

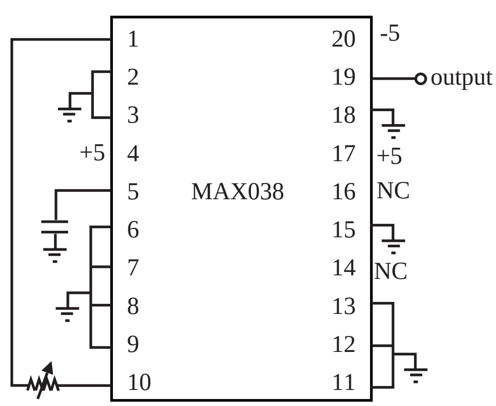

15 minutes
DELAY
Bank 1
Bank 2
(slow)
(rapid)
transitional area
transitional area
transitional area
control parameters gradually drift in and out of sync
DURATION
Modules 3,6
(long)
(short)
DURATION
Module 4
(long)
(short)
DURATION
Module 8
(long)
(short)
VARIANCE
All Modules
(high)
(low)

Chapter 3: Inside a Sound Module— A Technical Description

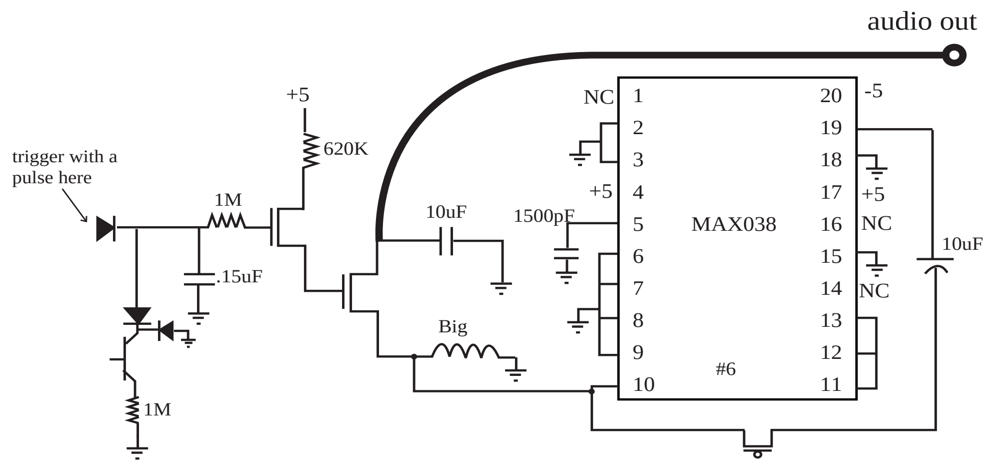
As discussed in Chapter Two, the heart of *Music for a Variety of Difficult Situations* are the eight 'sound modules.' These modules are responsible for all sound generation. This chapter will discuss their operation from a technical perspective, and will use sound module six as a model.

The Maxim Chip

All of the modules are based on modifications made to the Maxim 038 High Frequency Waveform Generator Chip. This chip is designed to generate a sine wave, a square wave, or a triangle wave from .1 Hz to 20 MHz. Typical applications include function generators, system clocks, pulse width modulators, and phase locking systems. It is designed to be extremely versatile and durable. Below is a typical implementation for sine wave operation according to the data sheet. (Appendix D)



The following modifications were made to the chip which were found to result in extremely unpredictable yet repeatable behavior. In particular, frequency sweeps, more complex waveform generation, and spontaneous harmonic noise bursts resulted. The circuit is triggerable with a single pulse, and the decay time of the circuit was made completely programmable.



Step by Step Discussion of Circuit

The following are the pins which are of particular interest, or to which modifications were made:

Pin 5— External capacitor. Controls frequency range.

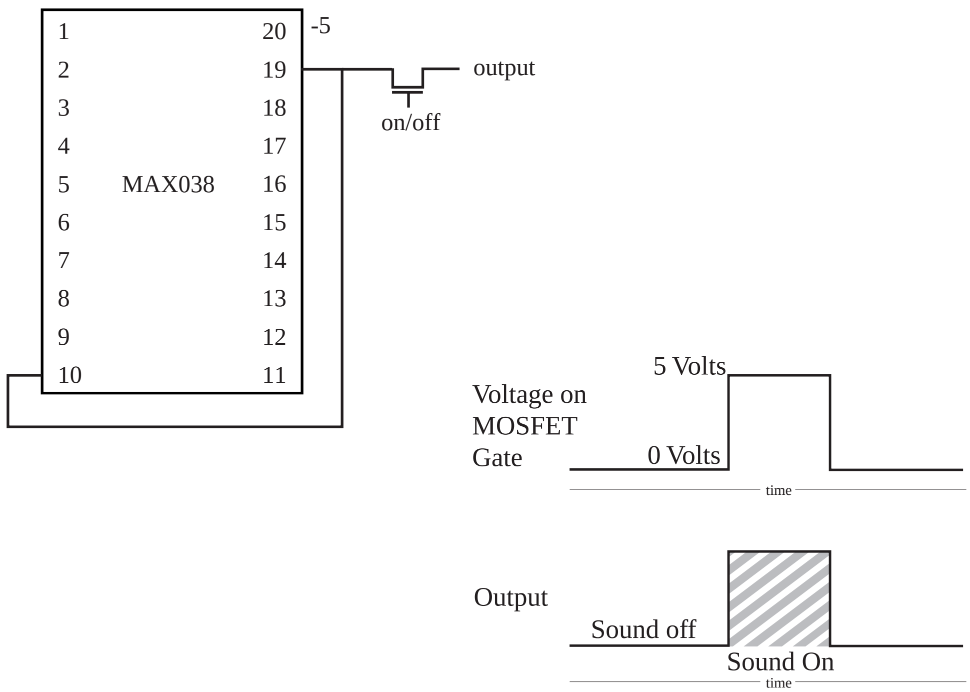
Pin 10— Current input for frequency control.

Pin 19— Sine wave output.

Pin 20— Negative supply input.

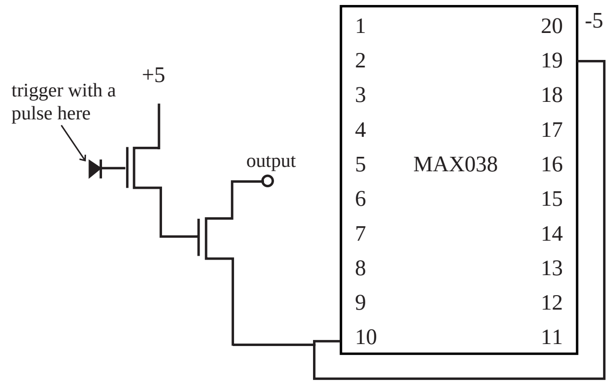
1. A continuous frequency modulated signal can be created by simply feeding the chip's output back into the control pin 10. A MOSFET is then added so that the output from the circuit can be turned on and off. Sound is present at the output for the period

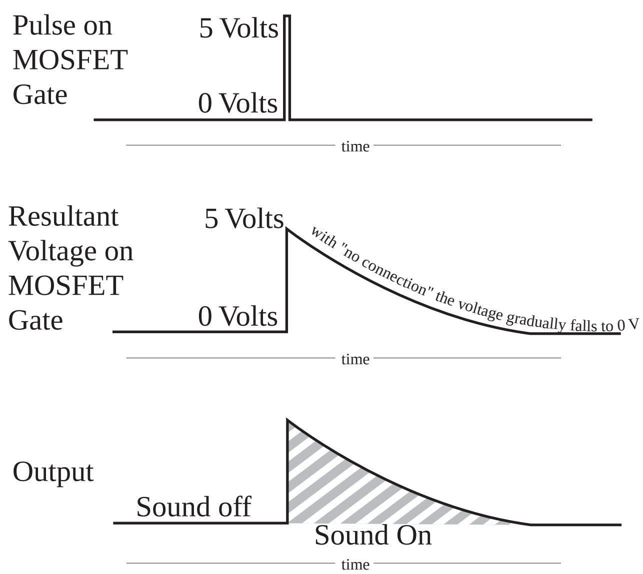
when the gate is at 5 volts.



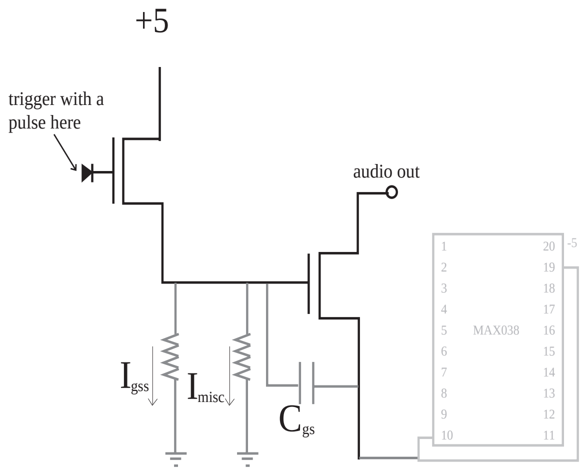
2. The circuit above results in extremely sharp on and off times (i.e. almost no decay). This is because the MOSFET is being driven with a +5 and ground pulse. This is standard MOSFET operation.

   However, if the gate was switched between +5 and ‘no connection,’ a more gradual decay would result. This was implemented as below. Notice that the source from the top MOSFET is connected to the gate of the lower. A diode is added to prevent reverse current flow, and was meant to simulate this ‘no connection’ or tri-state operation. In retrospect, only one MOSFET was probably needed, but it aids the diode somewhat in preventing reverse current flow. Also the extra parasitic capacitance was welcome.

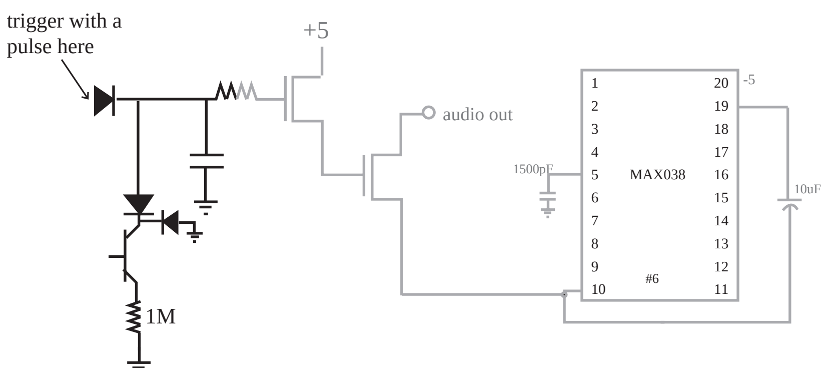




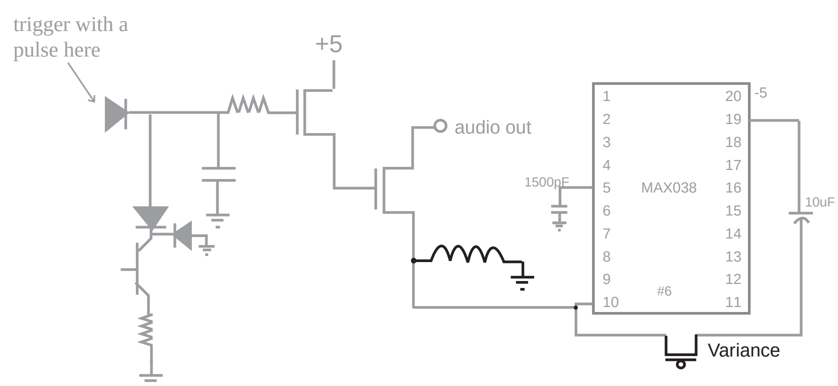
3. The decay time or duration of this circuit is directly related to an RC time constant, or how long the voltage on the gate is being held above ground. In this case, the C value is probably due to the parasitic capacitance between the gate and the source C_{gs}, while the R value is related to the I_{gss}, or the gate leakage current. Additionally, some current probably leaks through other parts of the circuit such as solder connections and is referred to as I_{misc} in the diagram below. I_{gss}, C_{gs}, and I_{misc} are not actual components, but characteristics of the MOSFET and circuit itself.



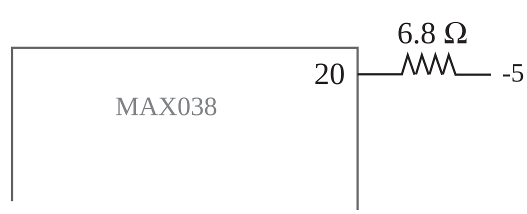
4. I_{gss} and C_{gs} are not reliable parameters, and I_{misc} can change with temperature and humidity. Also, it was found that when this module was connected to the rest of the circuitry, the decay time was found to be extremely short, probably less than a quarter of a second. It would be advantageous to be able to control the decay time. This could either be accomplished with a fixed resistor in parallel with a capacitor from the MOSFET's gate to ground, or alternatively with a fixed capacitor and a programmable current source such as transistor. With this latter option, decay times can be selected by changing the voltage on the base of the transistor. Two additional diodes were needed for practical reasons.



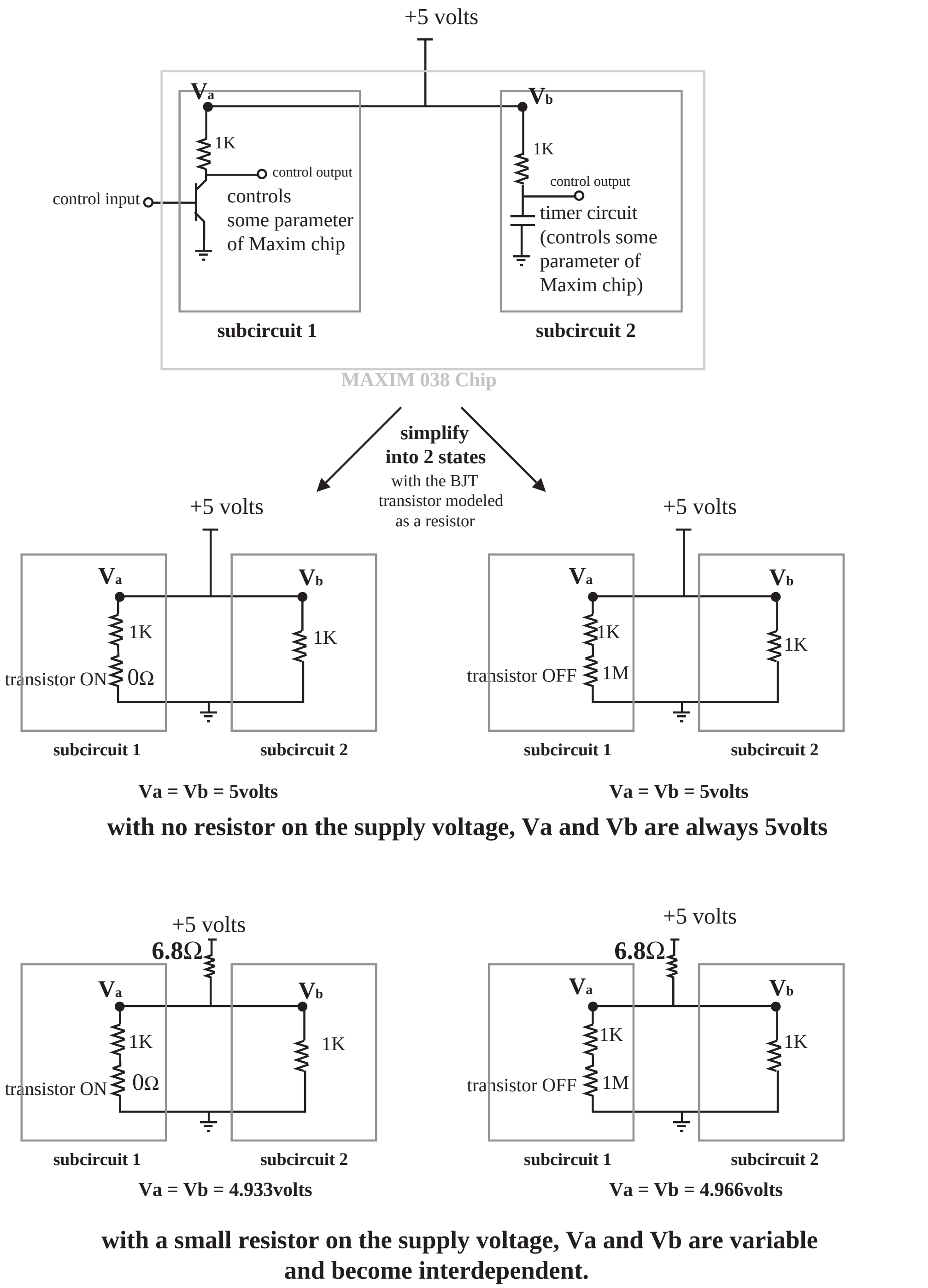
5. At this point in the development of the circuit, I still had a very simple waveform—a frequency modulated sine wave. By adding an inductor to the source of the second MOSFET, extremely wide and intermittent frequency sweeps occurred. I tried putting inductors of various sizes anywhere I could find a changing waveform. Only some of them resulted in musically useful behavior. A possible explanation for this unusual operation is the following: Since the current in a loop adjacent to the inductor is equal to the integral of the voltage across that inductor ($V_L = L(di/dt)$), a complex relationship between the output’s voltage and current is formed. In some case this mathematical function is then fed back into the chip’s control input or in other cases it is listened to directly. This feedback is controlled by the MOSFET labeled ‘variance.’



6. By limiting the current to the negative supply pin (pin 20), the circuit often seemed to decay into a very smooth harmonic noise. Other times, the circuit would change spontaneously into a very rough, almost square wave sounding passage. This is because the Maxim chip is comprised of many individual subcircuits. Many times these subcircuits are designed so that that they operate



independently from each other. By adding a resistor to the voltage source, the subcircuits can become coupled and interdependent, resulting in instability and unpredictable operation. This principle is illustrated below in a hypothetical integrated circuit. This simple modification added a tremendous amount of richness and texture to the sound.

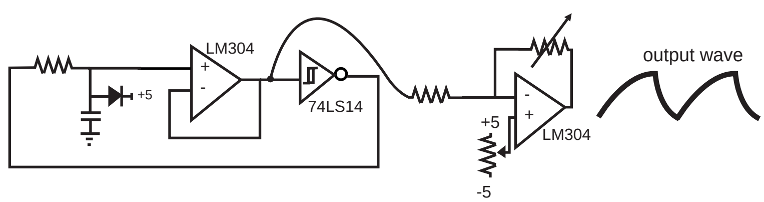


With a few more slight modifications, the circuit was completed. From this circuit, I developed seven similar modules. By simply changing the values of a few components, most notably the inductor values and the capacitor connected to pin 5, I was able to discover a wide variety of sounds.

A Hybrid Analog and Digital Asynchronous System

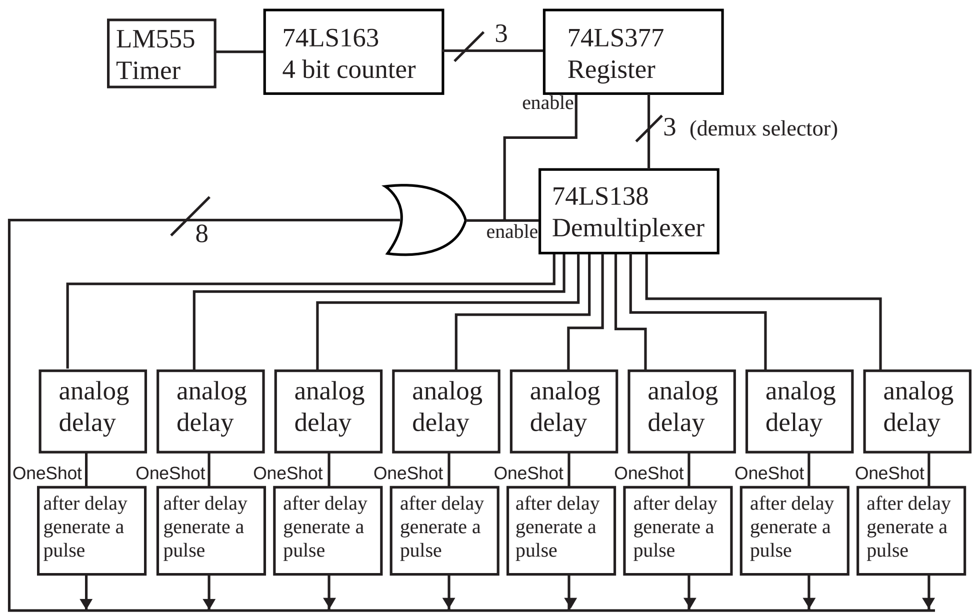
As mentioned in Chapter 2, the parameters of decay time (also referred to as duration) and variance change over time. This was accomplished by controlling the voltage which is applied to the base or gate of the duration and variance transistor.

This controller is simply a relaxation oscillator built around the concept of an RC time constant and an inverter. Below is the circuit as well as the resulting waveform. The voltage range is adjustable by changing external op amp resistor values.



There are four such relaxation oscillators. Each one is independent of the other, and they are not synchronized. The reason for this is that I wanted to avoid the rigidity of a fixed state machine, where every event is predictable and expected. The asynchronicity allows for a large number of possible sound combinations. In a sense, it is the system which decides when and for how long each event occurs. Of course, I designed that system, but I did not want to micromanage every event. It would be impossible to individually score every event of a perpetual machine.

The mechanism which controls the triggering and rhythm of events is discussed conceptually in great detail in chapter two. Below is a simplified schematic representation.



This selection circuitry is a combination digital and analog machine. The analog delays are independent timers which are controlled by another relaxation oscillator. These delays drift in and out of sync with the digital LM555 timer. This ensures that different events are chosen each time a HI is sent to the demultiplexer's 'enable' pin. However, since the digital timer is set to a modest 50Hz, and the timing of the analog delay circuits can be extremely accurate, the two timers can become locked. This results in a looping of a particular sequence of events and rhythm. This generally occurs every one to three minutes, with a repeating three second phrase looping two to eight times.

The design of this hybrid system was congruent with the style in which *Music for a*

Variety of Situations developed. I did not conceive of the entire schematic before it was constructed. Rather it was built slowly, one module at a time, with constant adjustments and redesign along the way. Variation and flexibility were the result of modularity, asyncronicity, and constant modification.

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